PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification [7] : B62D 25/00, E04C 2/26	A1	(11) International Publication Number: WO 00/43253
		(43) International Publication Date: 27 July 2000 (27.07.00)

(21) International Application Number: PCT/US00/00497

(22) International Filing Date: 27 January 2000 (27.01.00)

(30) Priority Data:

09/236,917	25 January 1999 (25.01.99)	US
60/133,375	10 May 1999 (10.05.99)	US
09/477,484	4 January 2000 (04.01.00)	US

(71) Applicant: HENKEL CORPORATION [US/US]; 2500 Renaissance Boulevard, Suite 200, Gulph Mills, PA 19406 (US).

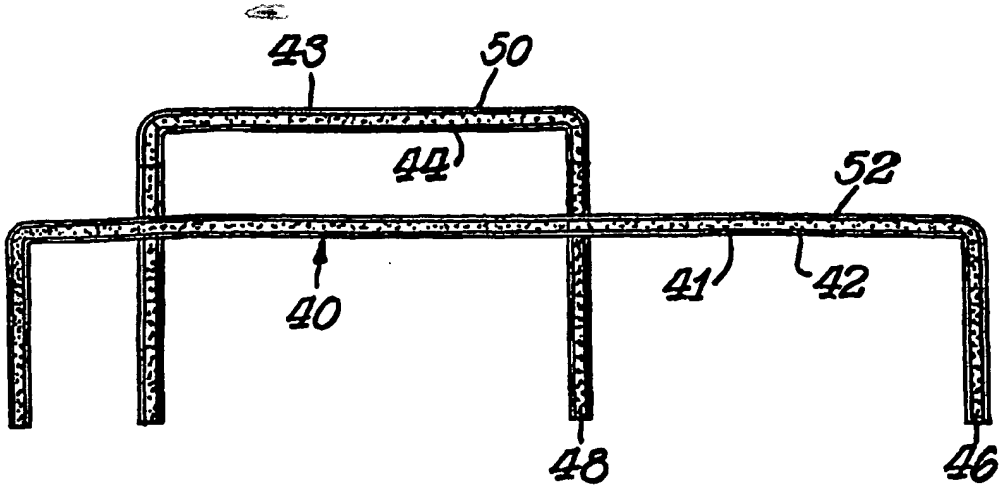
(72) Inventor: WYCECH, Joseph, S.; 795 Hidden Lane, Grosse Point Woods, MI (US).

(74) Agent: HARPER, Stephen, D.; Henkel Corporation, 2500 Renaissance Boulevard, Suite 200, Gulph Mills, PA 19406 (US).

(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: REINFORCED STRUCTURAL ASSEMBLY



(57) Abstract

A stiffener (18) is provided for reinforcing a hollow structure (10) having a pair of spaced walls. The stiffener includes a carrier member (22) with a layer of expandable polymer (20) which creates a structural foam when the polymer is later expanded. The stiffener (18) could comprise a single laminate shaped to fit in the appropriate locations of the hollow structure (10) so that when the polymer (20) is expanded it forms a structural foam intimately bonded to the pair of spaced walls. The stiffener may also be in the form of a corrugated frame (80) wherein individual laminates (82) are provided with notches (92) to permit the individual laminates (82) to be interlocked with each other at the notches (92).

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

REINFORCED STRUCTURAL ASSEMBLY

Cross-Reference to Related Application

This application is based upon provisional application Serial No. 60/133,375, filed May 10, 1999 and is a continuation in part of application Serial No. 09/236,917, filed January 25, 1999.

BACKGROUND OF THE INVENTION

In various practices it is desired to reinforce a hollow structural assembly, particularly structural members or sections which are subjected to edge or in-plane stresses which would tend to cause the structural member to buckle. Frequently holes are formed in structural members in order to weld internal reinforcements. Where, for example, the structural member is made of steel, a reinforcement is then welded to the structural member to prevent buckling. The holes would then be covered with cloth or plastic for appearance purposes.

It would be desirable if such hollow structural members could be reinforced by placing a reinforcement insert assembly into the hollow structure between the spaced walls in such a manner that would avoid the above problem. Typical applications for such practices could be in the automotive field, such as for reinforcing pillars. Other practices could be in the furniture field, such as

for office furniture end shelving units where shelves are locked into vertical end walls or panels.

SUMMARY OF THE INVENTION

An object of this invention is to provide a reinforced structural assembly which meets the above needs.

A further object of this invention is to provide such a reinforced structural assembly which includes a stiffener capable of being readily placed into the assembly.

A still further object of this invention is to provide techniques for reinforcing a structural assembly.

A further object of this invention is to provide such practices which could be used for various applications, such as in the automotive field or in the furniture reinforcement field.

In accordance with one embodiment of this invention a stiffener is formed by interconnecting sets of laminates. Each laminate preferably comprises a carrier member and a cover member with an expandable polymer layer between the members. Preferably the polymer is heat curable. Each laminate contains notches so that the laminates can be interlocked to form a corrugated frame or lattice which may be inserted into a hollow structure. Upon curing and expansion of the polymer a structural foam results which is intimately bonded to the spaced side walls

of the hollow structure. The hollow structure may, for example, be a pillar in an automobile or could be a hollow panel of a shelving unit.

In an alternative practice of the invention the stiffener could comprise an inverted U connected to an upstanding U with a common leg. An outward leg at one end of the laminate may extend upwardly beyond the remainder of the laminate so that the laminate could be placed in a lower pillar of a car at the junction of a hollow vertical section with a hollow horizontal section of the pillar for side impact or joint stiffening.

In a further alternative practice of the invention where the stiffener is a drop in insert for reinforcing a shelving unit, such as an office furniture end shelving unit. The laminate may be of straight linear construction and simply dropped into the unit so that the laminate extends generally from top to bottom of the hollow panel of the unit. In a variation the stiffener could be bent such as to form a generally zig-zag shape.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a partial side elevational view showing a door frame lower B pillar of an automobile with a stiffener mounted in place;

Figure 2 is a side elevational view of the stiffener shown in Figure 1;

Figure 3 is a right end elevational view of the stiffener shown in Figures 1-2;

Figure 4 is a perspective view of the stiffener shown in Figures 1-3;

Figure 5 is a view similar to Figure 1 of an alternative form of stiffener;

Figure 6 is a side elevational view of the stiffener shown in Figure 5;

Figure 7 is an end elevational view of the stiffener shown in Figures 5-6;

Figure 8 is a perspective exploded view of the stiffener shown in Figures 5-7;

Figure 9 is a front elevational view of a reinforced panel in an office furniture end shelving unit incorporating a stiffener in accordance with another alternative of this invention;

Figure 10 is a top plan view of the panel shown in Figure 9;

Figure 11 is a cross-sectional view taken through Figure 9 along the line 11-11;

Figure 12 is a view similar to Figure 11 showing the stiffener after expansion of the foam;

Figure 13 is a view similar to Figure 9 of a panel having an alternative view of stiffener in accordance with this invention;

Figure 14 is a top plan view of the panel shown in Figure 13;

Figure 15 is a cross-sectional view taken through Figure 13 along the line 15-15;

Figure 16 is a view similar to Figure 15 showing the foam in its expanded condition;

Figure 17 is a front elevational view of a reinforced panel for a shelving unit in accordance with still a further embodiment of this invention;

Figure 18 is a top plan view of the panel shown in Figure 17;

Figure 19 is a perspective exploded view of a portion of the stiffener shown in Figures 17-18;

Figure 20 is an elevational view of yet another practice of this invention;

Figure 21 is a cross-sectional view taken through Figure 20 along the line 21-21;

Figure 22 is a perspective view of a reinforced structural member in accordance with yet another practice of this invention;

Figure 23 is an enlarged end elevational view of the structure shown in Figure 22;

Figure 24 is a side elevational view of the reinforcement insert shown in Figures 22-23;

Figure 25 is a top plan view of the reinforcement insert shown in Figure 24;

Figure 26 is a perspective view of a reinforced structural member in accordance with an alternative practice of this invention;

Figure 27 is a perspective view of the reinforcement insert shown in Figure 26;

Figure 28 is a side elevational view of the reinforcement insert shown in Figures 26-27;

Figure 29 is a top plan view of the reinforcement insert shown in Figures 26-28;

Figure 30 is a side elevational view of one of the components of the reinforcement insert shown in Figures 26-29;

Figure 31 is a top plan view of the other of the components of the reinforcement insert shown in Figures 26-29;

Figure 32 is a perspective view similar to Figure 26 of yet another practice of this invention;

Figure 33 is a top plan view of the structure shown in Figure 32;

Figure 34 is a side elevational view of the structure shown in Figure 32-33;

Figure 35 is a perspective view of the reinforcement insert shown in Figures 32-34;

Figure 36 is a cross-sectional view taken through Figure 35 along the line 36-36;

Figure 37 is a perspective view showing a rein-forced structural member in accordance with yet another embodiment of this invention;

Figure 38 is a top plan view of the structure shown in Figure 37;

Figure 39 is a cross-sectional view taken through Figure 38 along the line 39-39;

Figure 40 is a side elevational view of a rein-forced structural member in accordance with yet another embodiment of this invention;

Figure 41 is a top plan view of the structural member shown in Figure 40;

Figure 42 is a fragmental perspective view showing a reinforcement insert in accordance with a further practice of this invention;

Figure 43 is a fragmental top plan view showing the reinforcement insert of Figure 42 mounted in a structural member before expansion of the foam;

Figure 44 is a view similar to Figure 43 after expansion of the foam;

Figure 45 is a perspective view of still yet another form of reinforcement insert in accordance with this invention;

Figure 46 is an end elevational view of the insert shown in Figure 45; and

Figure 47 is a perspective view of yet another form of reinforced structural member in accordance with this invention.

DETAILED DESCRIPTION

The present invention relates to techniques for reinforcing a hollow structural member having a pair of spaced walls so as to prevent buckling. In general, the techniques include providing a stiffener in the form of a carrier member having a layer of expandable polymer so that the stiffener can be readily disposed within the hollow structure between the spaced walls. The polymer is disposed for contacting the spaced walls when the polymer is expanded into a rigid structural foam. As will later be described, the stiffener can take various forms so as to maximize the reinforcing ability and the convenience of assembly of the stiffener.

Figure 1 illustrates a portion of a lower B pillar for an automobile door frame. The B pillar 10 includes a hollow frame having a generally vertical portion 12 joined to a generally horizontal portion 14. It would be desirable to reinforce the pillar at the junction of the vertical and horizontal portions and particularly to provide the reinforcement so as to interconnect the

opposite side walls of the pillar 10 for side impact or joint stiffening. One of the side walls 16 is illustrated. The other side wall would be parallel to and spaced from the illustrated side wall and would have generally the same configuration.

As shown in Figure 1 a stiffener is located within the hollow structure of pillar 10. Figures 2-4 best illustrate the details of stiffener 18. As shown therein a layer of polymer 20 is sandwiched between two support layers 22,24 to form a trilaminate. One of the layers, such as layer 22, would function as a carrier member while the other layer 24 would function as a cover member. Preferably, the layers 22,24 are made of metal, plastic or fiberglass material and preferably are rigid. The polymer layer 20 is preferably made of an expandable resin which upon expansion forms a structural foam or reinforcement that becomes intimately bonded not only to its carrier and cover members 22,24, but also to the spaced walls 16 of the hollow structure 10.

Although stiffener 18 may take any suitable shape, it is preferred to form the stiffener with a non-planar shape that provides for added height where the vertical portion 12 of pillar 10 meets the horizontal portion 14 and to provide greater length within the horizontal portion itself. By having a non-planar or bent

structure it is also possible to take into account the location of holes or any objects that might be within the pillar 10.

In the embodiment shown in Figures 1-4 the stiffener 18 is in the form of an upstanding U connected to an inverted U. The inverted U has a vertical leg 26 and an opposite vertical leg 28 interconnected by intermediate horizontal portion 30. The upstanding U has a vertical leg 32 and shares the common leg 28. Legs 28 and 32 are interconnected by horizontal portion 34. Each of the remote or outward legs 24,32 terminates in an outwardly extending flange 36. In this manner, the vertical leg 32 extends upwardly into the vertical portion 12 of the pillar while the horizontal connecting portion 30 and the vertical leg 24 extend outwardly into the horizontal portion 14 of pillar 10. Flange 36 extending from leg 24 also extends below connecting portion 34 as best seen in Figures 1-2.

Although Figures 1-4 illustrate a stiffener to have a double U shape, such shape may also be incorporated in other forms such as a W or M or U or V form.

Any suitable materials may be used for the polymer layer 20 and for layers 22 and 36. Reference is made to U.S. Patent Nos. 5,575,526 and 5,755,486, as well as application Serial No. 08/675,173 filed July 3, 1996, all of the details of which are incorporated herein by

reference thereto. It is preferable to use thin metal layers of sheet/foil thickness for the carrier member 22 and cover member 24. Plastic or fiberglass could also be used. It is also preferable to use a heat expandable resin for the polymer layer 20 which creates the structural reinforcement foam upon curing and expansion. Where the invention is used in an assembly line during vehicle production, the heating step could be accomplished in an oven conventionally used in such assembly lines without requiring a special added heating step. It is to be understood, however, that the invention may also be practiced where, for example, the resin is chemically cured in order to cause expansion.

Figures 5-8 illustrate a preferred variation of the invention wherein the stiffener 40 is made of a plurality of components which are interconnected to form a corrugated frame or lattice. Figure 6, for example, illustrates the stiffener 40 to comprise a pair of laminates 41 and 43. The laminates include U-shaped carriers 42,44 each of which has a layer 46,48 of polymer in its unexpanded condition similar to polymer 20. Preferably, a cover member 50,52 is provided over the polymer similar to the unit 18 described in Figures 1-4.

As shown in Figure 8 each U-shaped laminate 41,43 includes a notch or cutout 56,58 at a connecting portion of

the laminate so that the two laminates 41 and 43 may be interconnected by aligning the notches and then moving the two laminates together. The laminates 41 and 43 are of equal width, particularly at the connecting portions. Preferably, the combined length of the two notches 56,58 is equal to the width of each laminate at the connecting portion so that when the two laminates are interconnected, neither of the laminates extends outwardly of the other laminate. In other words, the front faces or walls of the two laminates are coplanar as are the rear faces or walls. Preferably, each notch extends about half-way into its respective laminate. Each notch has a width of 7.6mm.

The corrugated frame 40 would be placed in a hollow structure such as the pillar 10. The laminate 41 extends into the horizontal portion 14 of pillar 10, while the laminate 43 extends upwardly into the vertical portion 12 of pillar 10. Upon curing and expansion of the polymer 46,48, the resultant structural foam is intimately bonded to the pair of spaced walls 16 of pillar 10.

Stiffener 18 or 40 may be placed in the pillar in any suitable manner such as by being mounted in place before the two walls 16,16 are secured together. The result of incorporating the reinforcement unit in the pillar is to provide a side impact reinforcement or joint

stiffening which would be desirable for such structural member.

An example of use for the stiffener in automobiles would be to reinforce a rocker for a lower B pillar and the rear door of an automobile for side impact.

While the invention illustrated in Figures 1-8 has been described with respect to its practice in the automotive industry as a reinforcement for hollow structures, the invention may also be practiced in other fields. Figures 9-12, for example, illustrate the use of the invention in a hollow panel or side wall 60 which is part of a shelving unit wherein shelves are locked into the end walls of the end unit. As illustrated, panel 60 has a pair of spaced walls 62,62 forming a hollow cavity between the walls. The edges of the walls may be secured together at their flanges 64 by any suitable means such as spot welds 66. Disposed within the hollow space between the walls is a stiffener 70. As shown in Figure 11 stiffener 70 is a drop in insert which comprises a pair of spaced support members 72,74, similar to the carrier member and cover member of the stiffeners 18 and 40 and which are in contact with walls 62,62. Between the members 72,74 is a polymer layer 76, which is shown in Figure 11 in its unexpanded condition. Upon curing and expansion of the polymer, the

resultant structural foam expands into intimate contact with the walls 62,62 as illustrated in Figure 12.

Stiffener 70 could be mounted in the hollow space between walls 62,62 in any suitable manner. Preferably, the stiffener 70 could simply be dropped in from the top before any cap closes the top of the hollow space between walls 62,62.

As shown in Figure 9 the stiffener 70 is generally of a straight linear configuration in that it extends directly from one end to the other of the panel 60 in a straight path. If desired, a plurality of parallel spaced stiffeners 70 may be mounted between walls 62,62.

Figures 13-16 show a variation wherein the stiffener 70A is not a straight member, but rather is shaped or bent in a zig zag type manner. This version provides reinforcement over a greater area between the walls 62,62 as compared to the straight structure 70.

Figures 17-19 illustrate a preferred variation of the stiffener which is constructed along the same lines as the stiffener 40 in that a plurality of laminates are interconnected to form a corrugated frame or lattice. As illustrated, the stiffener 80 comprises a plurality of first laminates 82 and a plurality of second laminates 84 which extend crosswise the laminates 82. Each laminate comprises a pair of support members 86,88 between which is

sandwiched the polymer 90 in the manner previously described. The members 86,88 may thus be considered as a carrier member and a cover member for the polymer layer. Laminate 82 is provided with a plurality of notches 92 to mate with the corresponding notches 94 in laminate 84. Preferably, the combined length of each set of interlocking notches would be equal to the width of each laminate so that the resultant corrugated frame is of uniform thickness in that the laminates terminate coplanar with each other. Figures 17-18 show the placement of the corrugated frame 80 between the walls 62,62 of panel 60.

Although the various corrugated stiffeners illustrated herein show the interconnected laminates to be perpendicular to each other it is to be understood that the invention may also be practiced where the laminates are at a non-perpendicular angle with respect to each other. In such practices, the notches would preferably extend at an angle across each laminate.

The corrugated frame can readily be dropped in through the open top of the panel 60 or trapped between the panels during assembly and act as a brace which, because of its open areas, could be shaped to avoid holes and accommodate any irregularities in the panel.

In the various embodiments, the carrier member and cover member each may be made, for example, of .8mm of

galvaneal steel. The polymer layer before curing may be a strip of polymer 6mm by 75% of the spacing between the walls. The spacing between the walls 62,62 may be 25.4mm. The carrier and cover members may be 0.8mm thick.

As previously described, the preferred practice of the invention consists of a three layer reinforcement made up from two outer layers of metal, plastic, or fiberglass and an inner layer of heat curable polymer. The inner layer would be extruded onto one of the outer layers in a continuous fashion and the other outer layer would be rolled on top of the inner polymer layer. The sandwich would then be sent through a set of roll formers or pinch rollers, notched or trimmed, and then cut to length. The use of pinch rollers or a set of roll formers for the polymer and support member (one layer or two layers) shapes a cross section in a continuous manner for the laminate before being cut to length. Alternatively, the polymer and support member could be stamped to its desired shape by means of a chilled stamping die. The support member acts to assist in maintaining part shape and the cooling of the polymer layer in the stamping die or by ambient or chilled air in the roll forming process also "sets" the part shape. The coincidental forming of the polymer and support member at the same time differs from the current process which involves the separate forming of the polymer layer and

support member and then hand placement of the polymer layer onto the carrier/support member.

Separate pieces would be notched (if appropriate) and cut to length whereby one trilaminate snaps into another trilaminate such that a residential window grill or corrugated carton partition is formed. Figure 19 shows the simplest configuration which could be used for an office furniture end shelving unit. See Figure 17. Figures 6-8 shows this approach for a lower B pillar of a car for side impact or joint stiffening.

In the practice of the invention the two outer layers are rigid enough to support the diaphragms or stiffeners such that they retain their shape during forming, handling, and heat curing of the inner polymer layer and that they constrain the polymer such that the polymer expands in the plane of the laminate and consequently bonds to the walls of the hollow section to be reinforced. The interlocking nature of laminates allows for internal, self-supporting bulkheads to be placed in key areas of the hollow sections such that premature buckling of the parent or main hollow sections does not take place under applied loads.

A trilaminate is preferably formed by an in-line extrusion roll forming process such that trimmed, bent, notched, and cut lengths can be fabricated into interlock-

ing support shapes. The interlocking sections whether they be straight or bent can be used to reinforce hollow sections in key or critical areas thereby minimizing material usage through effective placement of the interlocking bulkheads or diaphragms. This approach lends itself to application in difficult areas to be reinforced. The interlocking laminates prevent thin section wall buckling due to wall stresses caused by bending or axial loading. Also, another important feature is that the two outside laminate skins or layers constrain the polymer towards bonding one side of the section to the other plus bonding the laminate layers to themselves. The interlocking trilaminate is another means of tying the side walls of a thin gage section together apart from filling a section solid with foam or lining the interior walls of a hollow section with a polymer laminate.

In practice, when forming the various stiffeners, a layer of polymer resin would be extruded onto the carrier member. In the broad practice of the invention the unit could include a laminate structure comprising only the carrier member and layer of resin. In the preferred practice, however, the cover member is added on the exposed side of the resin layer to sandwich the layer between the two support members. By having two support members the polymer is constrained and upon expansion of the foam the

members direct the foam into bonding contact with the thin walls of the hollow structure. Where the stiffener is formed in an in line process the laminate structure would then be chilled at, for example, a temperature in the range of 0° to -40°F. After chilling any necessary trimming or notching could be done using any suitable techniques such as die cutting or the application of a water jet. The laminate would then be cut to length and where necessary would be bent to its desired shape. Where the unit is a corrugated frame the individual laminates would then be interlocked with each other at the notches formed in the connecting portions of the laminate.

Figures 20-21 show a variation of the invention. As shown therein, the trilaminate stiffener 96 is in the shape of a horseshoe placed over the pin 98 and seated on the bottom of the rail 99. Rail 99 may include dimples 97 which penetrate the foam layer to hold the stiffener 96 in place. Preferably the stiffener 96 is made in-line, extruded, die cut in its flat condition and then bent to the final profile.

As is apparent one aspect of the invention involves a stiffener for reinforcing a hollow structure having a pair of spaced walls. The stiffener comprises a carrier member with a layer of expandable polymer on the carrier member and a cover member on the polymer layer.

The stiffener is of non-linear shape, such as a W, M, U or V shape or some other irregular shape.

Figures 22-47 relate to variations of the previously described techniques. In the following description reference will be made to various structural arrangements and materials. It is to be understood that these details are considered exemplary of various practices of the invention and that the various shapes, relationships and materials disclosed in prior practices may also be utilized in the various practices of Figures 22-47.

Figures 22-25 illustrate one practice of this invention which involves the reinforcement of a channel shaped structural member 110 by means of a drop in reinforcement insert 112. In the illustrated embodiment structural member 110 is a truck pickup floor beam. Reinforcement insert 112 is in the form of a convoluted trilaminate which functions as an internal spacer to maintain the cross sections during gross beam deflection. This approach is similar to the convoluted trilaminate previously described, particularly for furniture application except that in the prior embodiment the trilaminate is loaded in tension in the narrow direction. In the embodiment illustrated in Figures 22-23, for the pickup beam, for example, the trilaminate reinforcement 112 is loaded in compression in the short or narrow direction. The trilami-

nate would comprise a central layer 111 of structural foam with an outer layer 113 functioning as a carrier and/or cover or support layer on each side of the structural foam as described in the prior application.

As illustrated the convoluted shape need not be uniform in its degree of convolution. Thus, for example, the central portion of the reinforcement insert 112 could have its bent sections spaced closer together than at the end portions. This is best shown in Figures 22 and 25.

Figures 26-31 illustrate a further practice of this invention. As shown therein the reinforcement insert 114 or trilaminate is mounted in the channel of a front rail 116 of an automotive vehicle behind the front wheels and underneath the tow board. This trilaminate reinforcement insert 114 is in the form of a curved generally vertical wall 122 having flat sides and which runs in the area of maximum vertical concurvature in the side view on the bottom of rail 116, as shown in Figure 26. In discrete sections or locations along the trilaminate length it would be desirable to install horizontal bulkheads 118 which are also in the form of trilaminates cut to fit the vertical wall 122. Figures 30-31, for example, show the vertical wall 122 to have a slot 117 and the bulkhead or horizontal wall 118 to have a slot 119. The vertical wall 122 and horizontal bulkhead 118 are thus joined together by

engagement at the slots 117 and 119. Alternatively, the bulkheads 118 could be located by means of tabs that key into holes or slots 120 in the vertical walls 122 of the main component trilaminate insert 114 as shown, for example, in Figures 35-36. The horizontal bulkheads 18 would function to prevent lateral buckling of the rail section in a local area. The main vertical reinforcement 122 is used to prevent buckling in the rail vertical or side view direction. The horizontal bulkhead 118 forms a cross brace for the rail section when it is slipped into the vertical member 122.

The various components of reinforcement insert 114 may be custom shaped in accordance with the end use. For example, as illustrated the vertical member 122 may include an arcuate wall 115 which may be semi-cylindrical in shape to clear a pin located in the structural member so that the assembled rail components could be welded to each other.

The various figures also illustrate a clearance hole 121 in the bulkhead or horizontal member 118 for the fastener.

Figure 29 best illustrates a practice of the invention where the thickness of the vertical member 122 varies from one end to the other. Thus, for example, the end on the left hand portion of Figure 29 is twice as thick

as the remote end on the right hand portion with the thickness uniformly tapering from one end to the other. The laminate 122 might thus be 8 mm thick at one end and 4 mm thick at the other end.

Figures 32-36 illustrate a practice of the invention very similar to that of Figures 26-31 except that in Figures 32-36 the vertical member 122 is in the form of vertical pleats which run in the area of maximum vertical curvature in the side view of the bottom rail 116 as shown in Figure 34. The main function of the convolutions of reinforcement insert 114 is to stabilize the vertical web from buckling in the lateral or horizontal direction. A vertical wall will buckle under a smaller compressive load than a wall that has a series of vertical stiffeners or convolutes. This also applies to the web trapped between the two horizontal bulkheads 118,118. At this location the convolutes act as miniarches to support the horizontal bulkheads and consequently the main rail section.

Figures 37-39 represent an application for non-automotive use in which a recessed floor 124 is capped with a piece of sheet metal 126 that is hemmed over the four perimeter flanges 128 around the recessed area to form a pan. This part may be used, for example, for computer room sub-floors to isolate computer equipment from cabling

underneath. Thus, the pan 126 includes, in effect, creates a pit 130 in the recessed floor 124 to accommodate electrical wiring and cooling equipment. The assembled pans 126 are supported by a metal grillage and the pans are dropped into the grillage and hung from their flanges. The current method to reinforce the pans is to fill the pans with concrete, but this method yields a heavy part which is difficult to install and messy to fabricate. In accordance with the invention the concrete is replaced with a trilaminate partition 132 formed by interlocked supports 133,135 to form a grid. As best shown in Figures 37 and 39 supports 133 and 135 terminate in ends 134 having a horizontal lower surface for placement on horizontal pans 126. Inwardly of ends 134, each support 133,135 is downwardly inclined to the center of partition 132. This arrangement assures a self centering of partition 132 in pan 126 because the spacing between the opposite horizontal ends 134 from the points where the ends begin to taper would be equal to the spacing between opposite sides of pan 126. Additionally, the downward taper of supports 133,135 means that there is an increased amount of reinforcement into pit 130. Alternatively, each support 133,135 may have its ends 134 comprise flanges of otherwise rectangularly shaped supports, rather than tapered supports. Figure 39

illustrates the supports to terminate a distance above floor 124. This spacing and the tapered lower edges of supports 133,135 assures providing sufficient room in pit 130 to accommodate wiring, etc. An alternative would be to form the minibeams into interlocking arches that are bearing on the bottom of the pit. Prior embodiments illustrate various manners of forming a partitioned reinforcement. Thus, the computer floor module 24 is effectively supported.

Figures 40-44 illustrate a variation of a stiffener 136 which is in lattice form comprising a plurality of first laminates 138 and a plurality of second laminates 140 extending cross wise to the laminates 138. Each laminate comprises a pair of outer support members 142,144 between which is sandwiched the polymer 146. Each laminate 138,140 is provided with a plurality of notches 148,150 so that the notches may mate with each other to create an interlocked structure forming the reinforcement 136. Figures 43-44 show the laminate structure between walls 152,154 of a member which is intended to be reinforced. Figure 43 shows the arrangement before the polymer 46 has expanded, while Figure 144 shows the polymer 146 expanded into a structural foam intimately bonded to each side wall 152,154.

In accordance with a further feature of this invention mechanical staples 156 are used to keep the trilaminate structure together and allow the polymer 146 to expand in the plane of the laminate in order to tie the two opposing sides 142,144 together and ultimately to tie the sides 152,154 together. The staples keep the metal sides 142,144 from bulging and moving laterally and force the polymer expansion to the opposing walls 152,154 that are to be reinforced and tied together.

Figures 45-46 show a further reinforcement insert 158 in accordance with another embodiment of this invention. Such insert might be used, for example, to reinforce the lower B pillar of an automobile. As shown therein, one trilaminate member 160 would slide into an elongated notch 162 of the perpendicular trilaminate member 164. If desired, surface interruptions, such as holes 166 or further notches 168 or tapers 170, may be provided on the laminate members to accommodate the shape of the structural member being reinforced.

Figure 47 shows yet another practice of this invention wherein the reinforcement insert 172 is in the form of a tube 174 completely peripherally wrapped with polymer 176. For example, the tube 174 could be of 0.8mm cold rolled steel wrapped on all four sides with the

polymer. The wrapped tube could then be inserted into an A pillar section and cured under E coat oven conditions. This form of laminate is a two-layer laminate rather than a trilaminate. It has been proposed by others to reinforce an A pillar cross-section by means of an aluminum extrusion cross or plus sign tipped with an adhesive polymer. Such arrangement has various drawbacks when using this form of aluminum cross like structure. For example, the part has to be extruded in a straight section with the curvature being a secondary forming step. The cross would be very difficult to bend because it is not a tube and it could not hold its shape well and would distort. The part could not be extruded in a metal thickness less than 1.5mm and most preferably 2.0mm. The larger the section the more aluminum is required thus making this approach less competitive. In addition, in order to make the extrusion effective the webs, flats or walls of aluminum have to be normal or 90° to the wall or roof which they are bracing. Any off angle position would cause the reinforcement to slip from under their support. The polymer could not be strong enough to resist this underpinning failure. There would also be a problem with snaking a straight edge of the aluminum extrusion between holes. To clear holes the extrusion would have to be

notched which results in additional cost. Since most of the automotive sections are never constant over their length additional edge polymer would have to be used to compensate for widening gaps. This could result in trimming the length of the part to fit or result in loss of reinforcing efficiency since the reinforcement could slip or rotate within in the main hollow cross section. Once the extrusion dies are set, part changes result in tool changes and loss of time, although aluminum dies are not expensive.

IN THE CLAIMS:

1. A stiffener for reinforcing a hollow structure having a pair of spaced walls, said stiffener comprising a first carrier member, a first layer of expandable polymer on said first carrier member for creating a structural reinforcement foam when said polymer is expanded, said first carrier member and said first layer comprising a first laminate, a second carrier member, a second layer of said polymer on said second carrier member, said second carrier member and second layer comprising a second laminate, said first laminate having a connecting portion, a notch in said connecting portion of said first laminate, said second laminate having a connecting portion, a notch in said connecting portion of said second laminate, said first laminate and said second laminate being interconnected by said connecting portions being interlocked at said notches, and said connected laminates creating a corrugated frame which

may be inserted into the hollow structure between the spaced walls.

2. The stiffener of claim 1 including a first cover member mounted over said first layer to comprise part of said first laminate, a second cover member mounted over said second layer to comprise part of said second laminate, and said carrier member and said cover member being rigid.

3. The stiffener of claim 2 wherein said connecting portions are generally perpendicular to each other.

4. The stiffener of claim 2 wherein said connecting portion of said first laminate has the same width as said connecting portion of said second laminate, each of said notches extending into its respective laminate a distance wherein the combined distance of the interconnected notches is equal to said width of said connecting portions so that said connecting portions have coplanar outer edges.

5. The stiffener of claim 4 wherein each of said first laminate and said second

laminate is U-shaped, said first laminate being longer than said second laminate, and said second laminate being higher than said first laminate.

6. The stiffener of claim 5 wherein each of said notches extends about halfway through its respective first laminate and second laminate, and said carrier member and said cover member each being made of a rigid material.

7. The stiffener of claim 5 in combination with a hollow structure which is part of an automobile.

8. The stiffener of claim 7 wherein said hollow structure is a pillar having an elongated hollow vertical portion connected at a junction to an elongated horizontal portion, and said stiffener being located at said junction.

9. The stiffener of claim 4 wherein there are a plurality of said first laminates and a plurality of said second laminates, each of said first laminates having a plurality of said notches, each of said second laminates

having a plurality of said notches, and said plurality of said first laminates being connected to said plurality of said second laminates by the interconnection of said plurality of said notches.

10. The stiffener of claim 9 wherein each of said first laminates and said second laminate is of straight linear shape.

11. The stiffener of claim 10 in combination with a shelving unit having a hollow side panel which comprises said hollow structure, said stiffener being located in said hollow structure, and said structural foam being intimately bonded to said spaced walls of said panel.

12. The stiffener of claim 2 wherein said second laminate comprises a bulkhead of lesser length than said first laminate.

13. The stiffener of claim 12 wherein at least a portion of said first laminate is curved.

14. The stiffener of claim 12 wherein said bulkhead extends at a non-perpendicular angle to said first laminate.

15. The stiffener of claim 12 wherein said first laminate is in the form of pleats.

16. The stiffener of claim 2 wherein a plurality of said first laminates are connected to and across a plurality of said second laminates to form a grid.

17. The stiffener of claim 16 including a pan having an open central area, and said grid being mounted on said pan over said central area.

18. The stiffener of claim 17 wherein each of said laminates has a lower surface and free ends, said free ends being on said pan, and said lower surfaces intermediate said free ends extending into said central area.

19. The stiffener of claim 2 including fasteners extending through said polymer layer connecting said carrier member and said cover member together.

20. The stiffener of claim 2 wherein at least one of said laminates includes surface interruptions.

21. A stiffener for reinforcing a hollow structure having a pair of spaced walls

said stiffener comprising a laminate including a carrier member, a layer of expandable polymer on said carrier member, and said laminate being of non-linear shape.

22. The stiffener of claim 21 wherein said laminate includes a cover member on said layer of expandable polymer.

23. The stiffener of claim 22 wherein said non-linear shape is selected from the group consisting of W, M, U and V shapes.

24. The stiffener of claim 22 wherein said non-linear shape is an upstanding U connected to an inverted U, said upstanding U having a pair of vertical legs and a horizontal connecting section, said inverted U having a pair of upstanding legs and a horizontal connecting section, one of said legs of said upstanding U being a leg common to said inverted U, the other of said legs of said upstanding U being an outward leg and the other of said legs of said inverted U being an outward leg, and one of said outward legs extending above the remaining

of said legs and above said horizontal connecting sections.

25. The stiffener of claim 24 wherein said carrier member and said cover member are rigid.

26. The stiffener of claim 26 wherein the other of said outward legs terminates below the remaining of said legs and below said horizontal connecting sections, and said polymer being heat expandable.

27. The stiffener of claim 26 in combination with an automobile pillar having an elongated vertical portion connected at a junction to an elongated horizontal portion, and said stiffener being located at said junction.

28. The stiffener of claim 24 wherein said non-linear shape is a zig-zag shape.

29. The stiffener of claim 27 wherein at least a portion of said laminate is curved to comprise said non-linear shape.

30. The stiffener of claim 22 wherein said laminate varies in thickness throughout its length.

31. The stiffener of claim 22 wherein said non-linear shape is a horseshoe shape.

32. The stiffener of claim 21 wherein said non-linear shape is a closed tube, and said layer of expandable polymer being an exposed outer layer of said laminate.

33. In a shelving unit having a hollow vertical panel formed by spaced walls, the improvement being a stiffener mounted in the spacing between said walls, said stiffener comprising a first support member and a second support member spaced from each other, a layer of expandable polymer mounted between said first support member and said second support member for creating a structural reinforcement foam when said polymer is expanded, said first support member and said second support member extending across said spacing into contact with said side walls, said foam upon expansion being bonded in intimate contact with said side walls and with said members, and said stiffener extending generally vertically down said spacing.

34. The shelving unit of claim 33 wherein said stiffener extends in a straight linear direction down said spacing.

35. The shelving unit of claim 34 wherein said stiffener is bent and extends down said spacing in a non-straight linear pattern.

36. A method of making a stiffener and reinforcing a hollow structure with the stiffener comprising the steps of mounting a layer of expandable polymer on a carrier member to create a laminate, cutting the laminate to a predetermined length and thereby creating a stiffener, disposing the stiffener between spaced walls of the hollow structure, and curing and expanding the polymer to create a structural reinforcement foam which becomes intimately bonded to the spaced walls and to the members.

37. The method of claim 36 wherein the layer of polymer is mounted on the carrier member by extruding the layer on the carrier member, and rolling a top member on top of the polymer layer to create a trilaminate.

38. The method of claim 37 including bending the trilaminate to a predetermined shape.

39. The method of claim 38 including trimming and notching the trilaminate before it is cut to length, interconnecting the trilaminate with a further trilaminate to form a corrugated frame, and the corrugated frame comprising the stiffener.

40. The method of claim 39 including chilling the trilaminate before it is bent.

41. The method of claim 39 including mounting the stiffener into an automobile lower pillar which comprises the hollow structure.

42. The method of claim 39 including mounting the stiffener into a hollow panel of a shelving unit which comprises the hollow structure.

43. The method of claim 38 including mounting the stiffener into an automobile lower pillar which comprises the hollow structure.

44. The method of claim 38 including mounting the stiffener into a hollow panel of a

shelving unit which comprises the hollow structure.

45. The method of claim 36 wherein the laminate is passed through a set of roll formers to shape its cross section in a continuous manner before being cut to length.

46. The method of claim 36 wherein the laminate is chill stamped into shape as the cutting step.

47. The method of claim 36 wherein the laminate is bent to a non-linear shape after the cutting step.

Fig. 4.

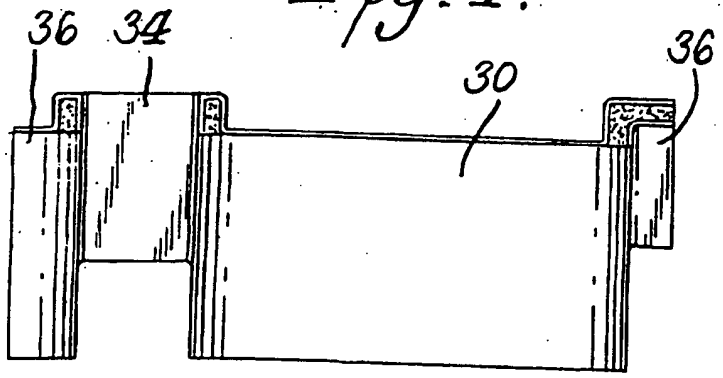


Fig. 2.

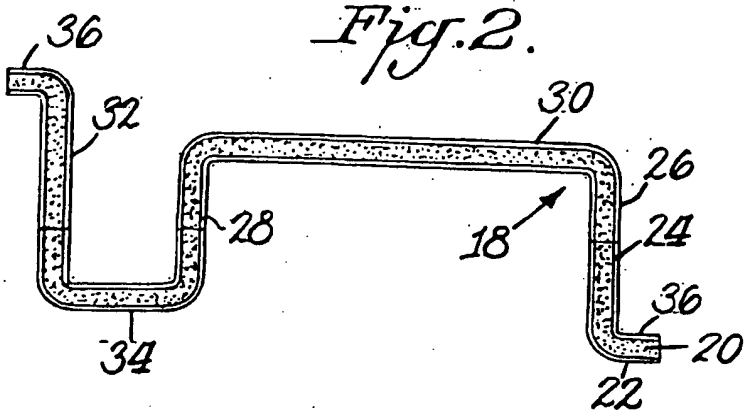


Fig. 3.

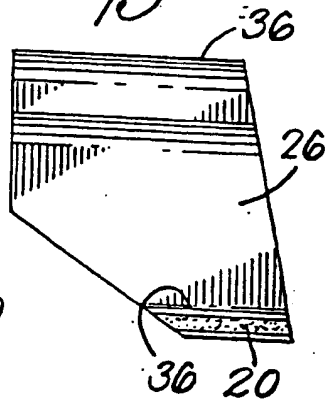
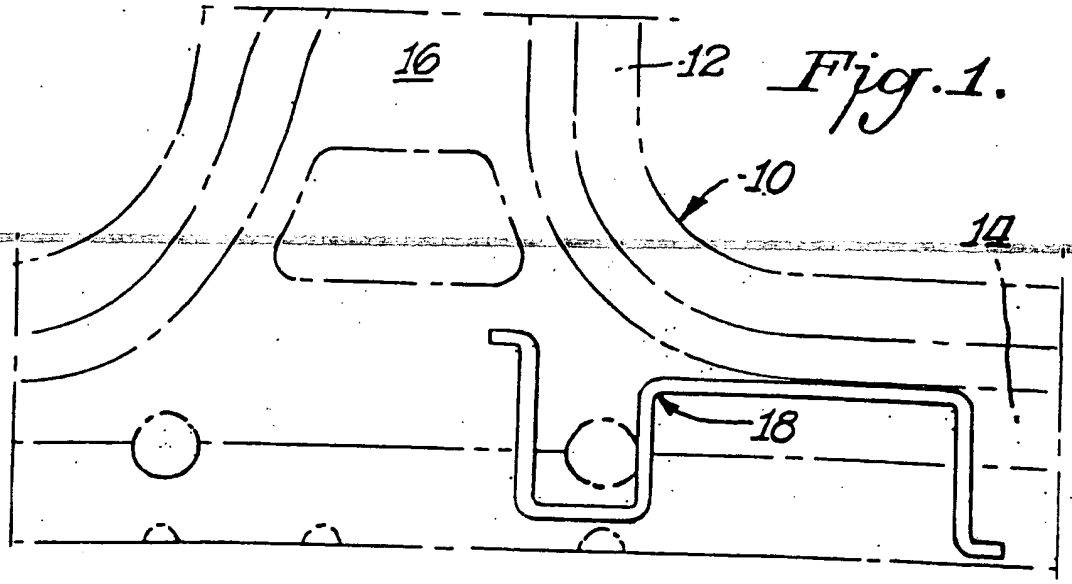


Fig. 1.



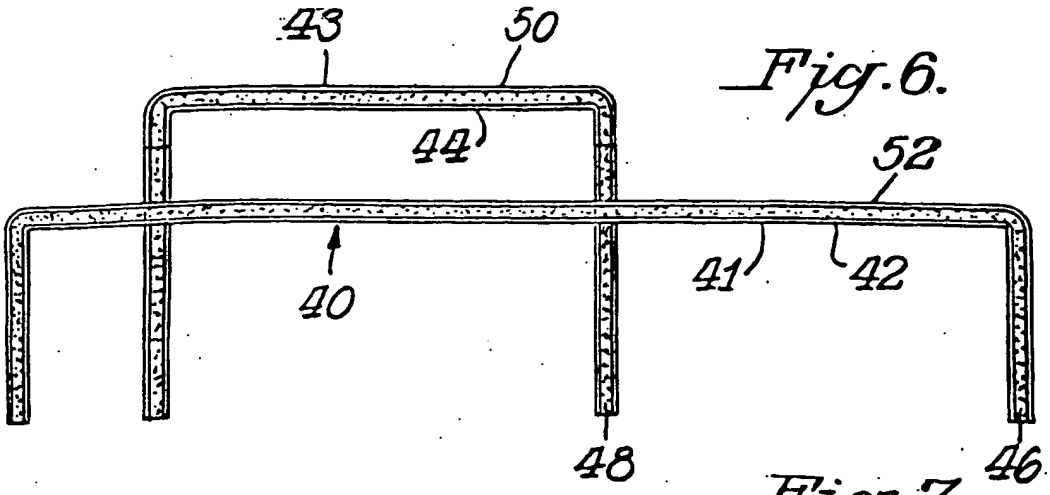


Fig. 6.

Fig. 7.

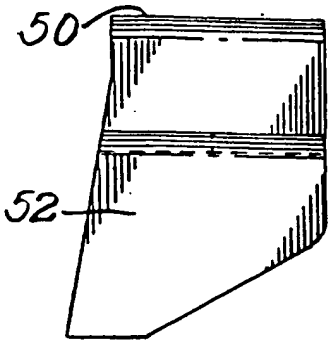
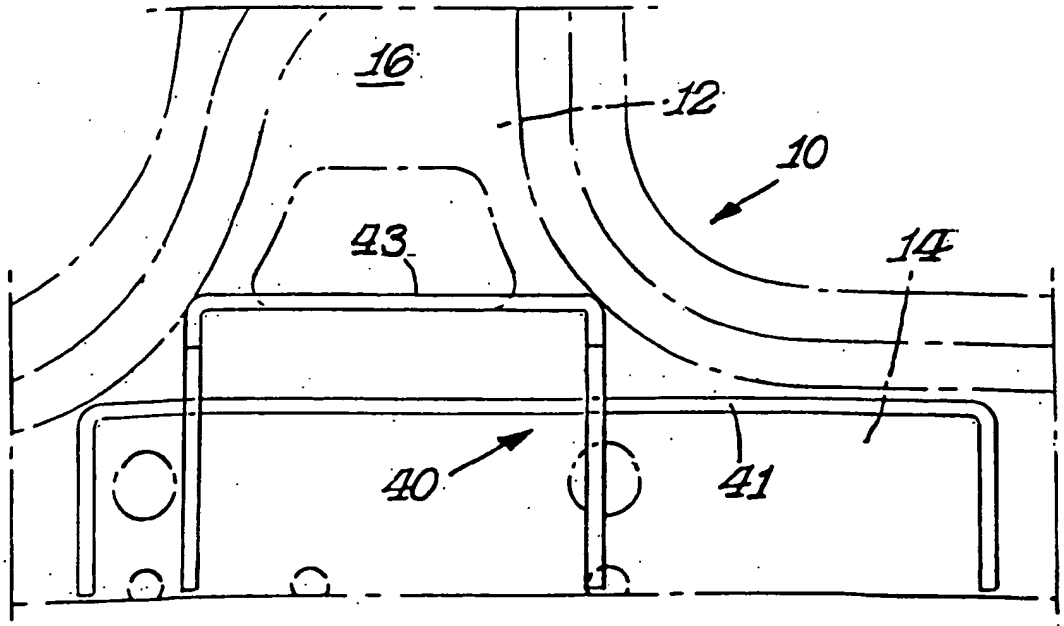


Fig. 5.



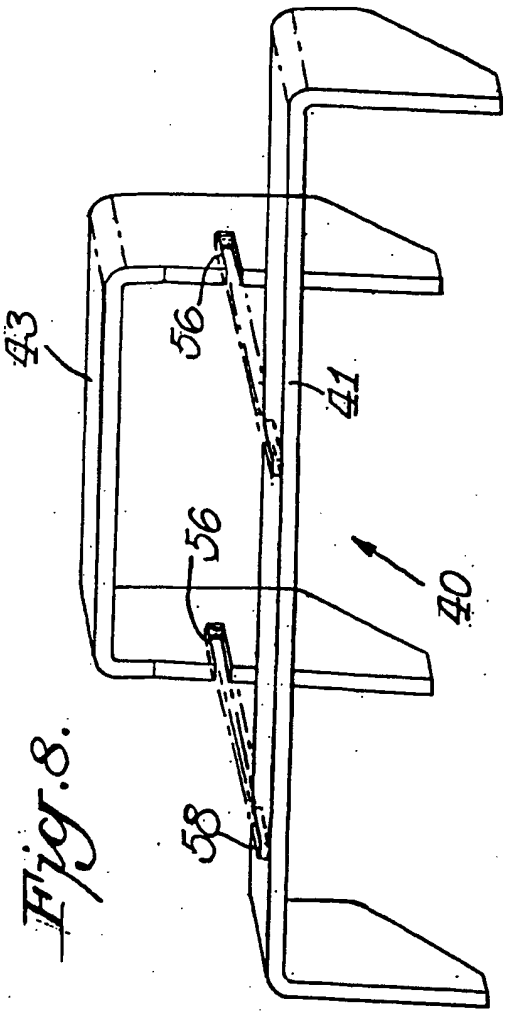


Fig. 8.

Fig. 10.

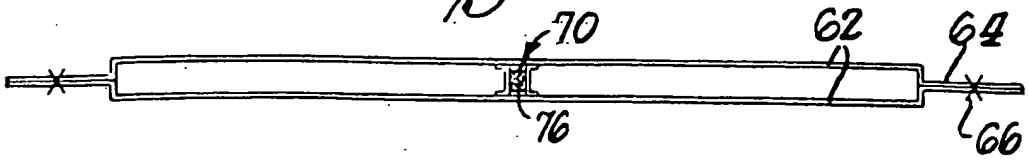


Fig. 9.

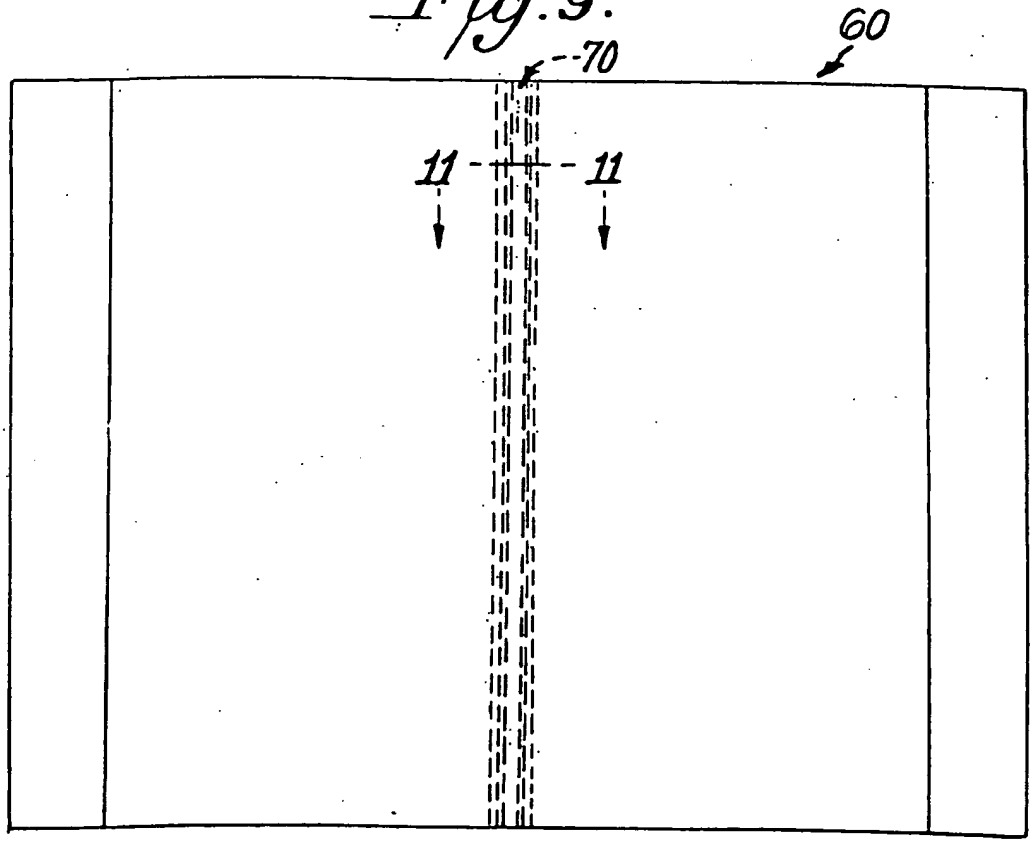


Fig. 11.

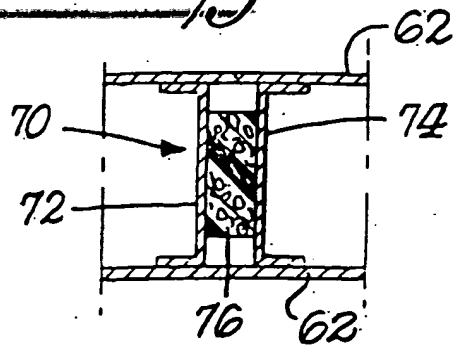


Fig. 12.

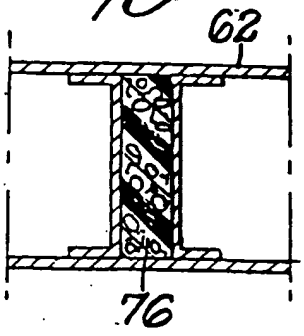


Fig. 14.

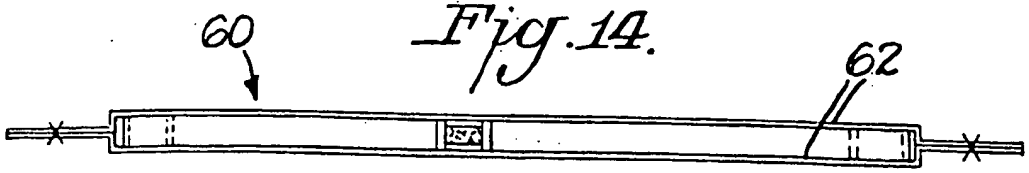


Fig. 13.

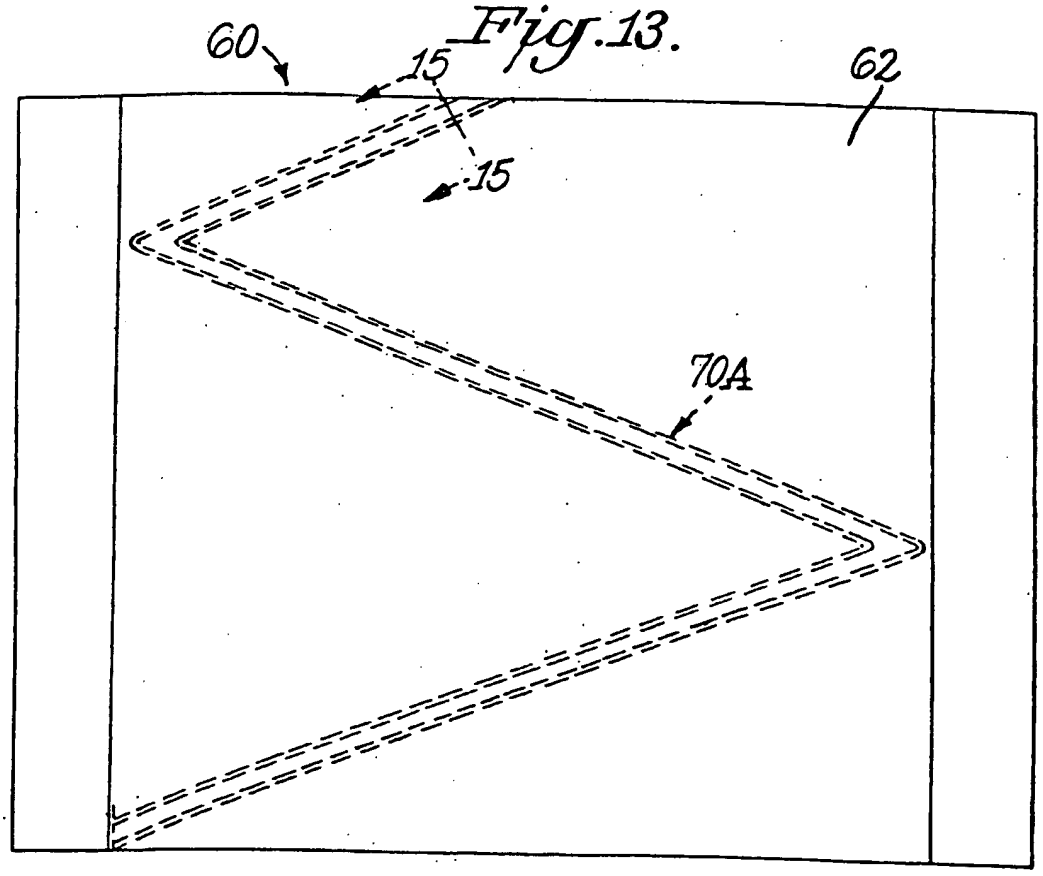


Fig. 15.

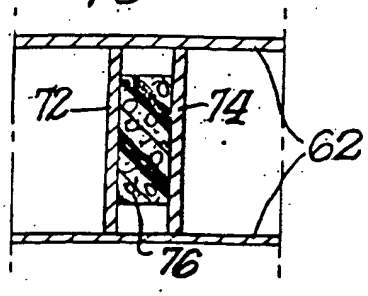


Fig. 16.

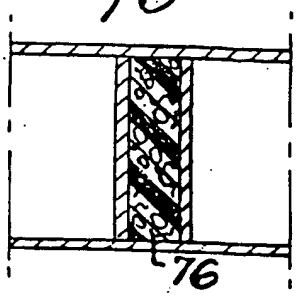


Fig. 18.

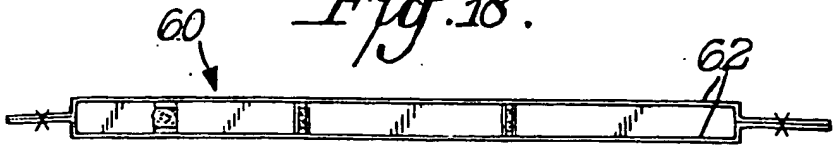


Fig. 17.

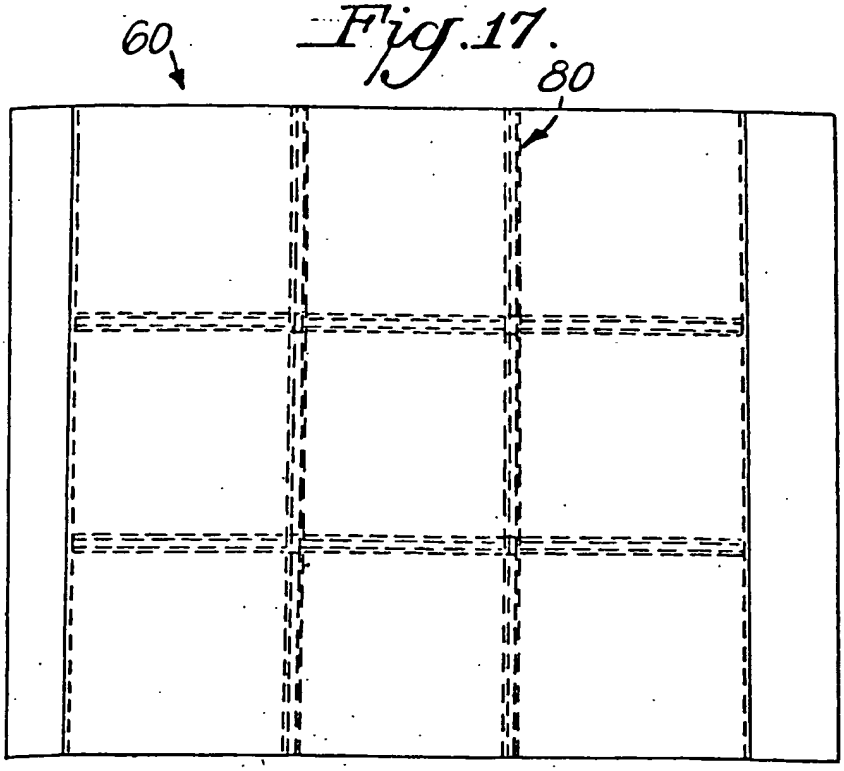


Fig. 19.

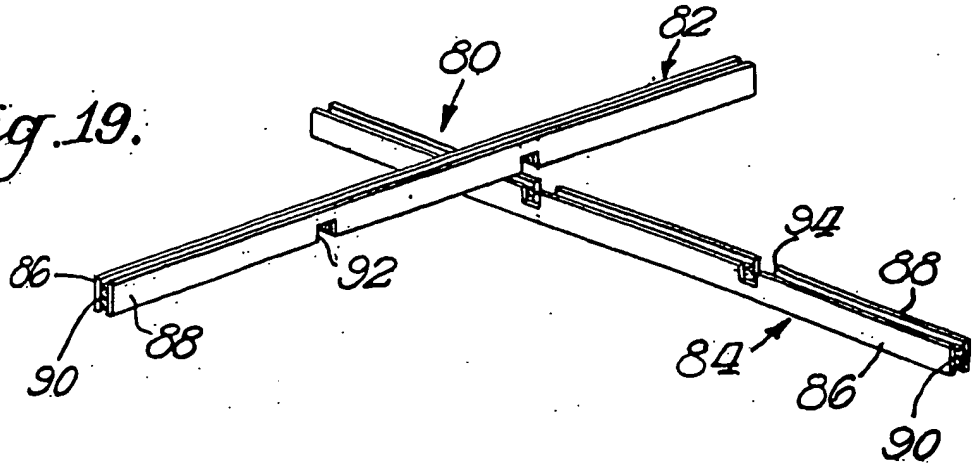


Fig.20.

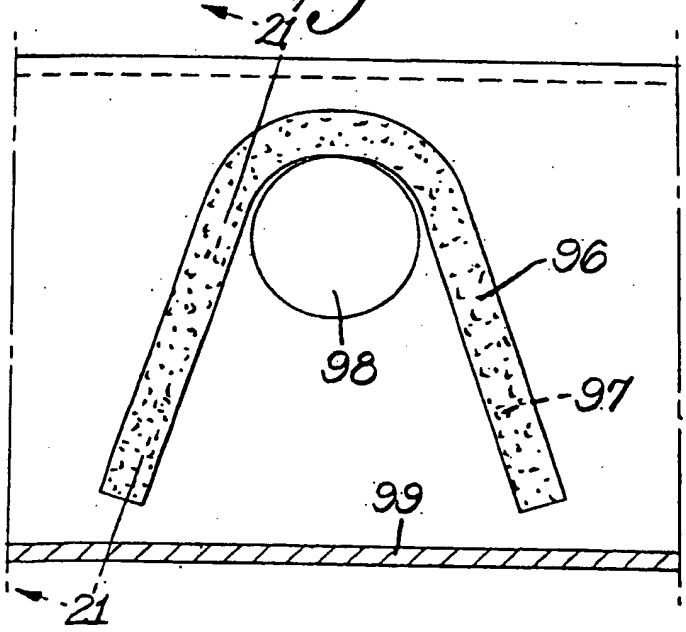


Fig.21.

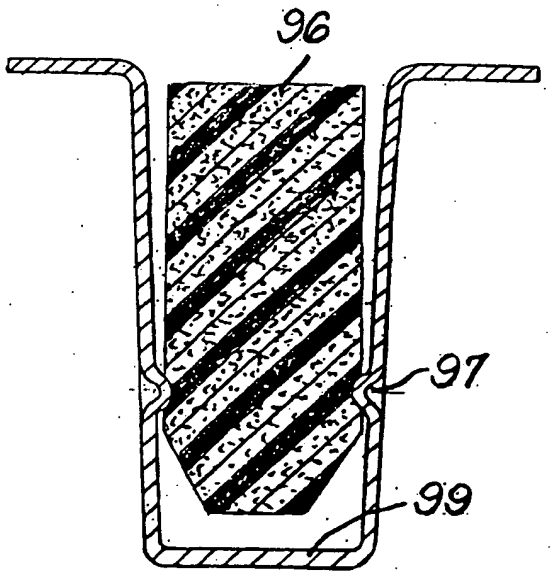


Fig. 22.

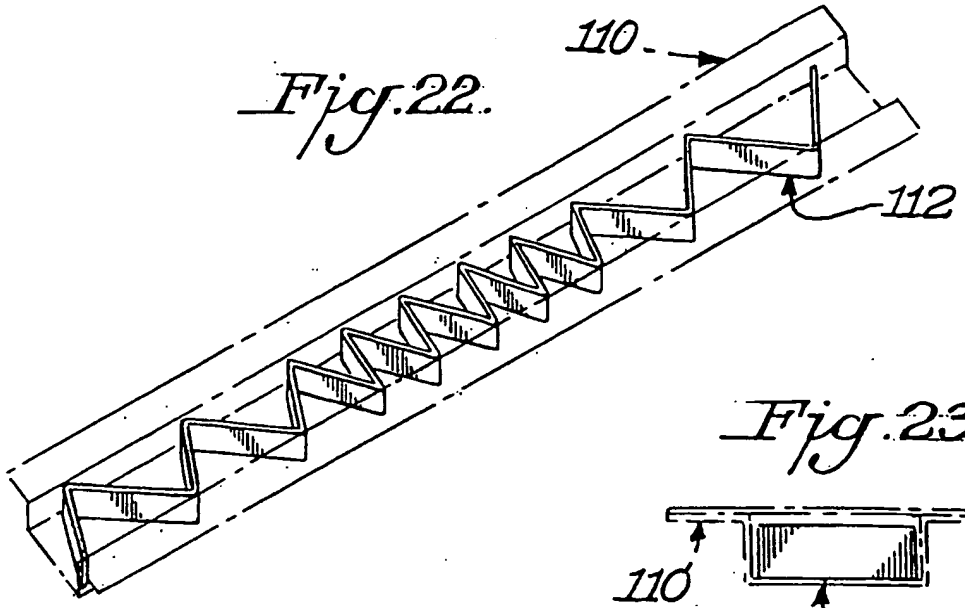
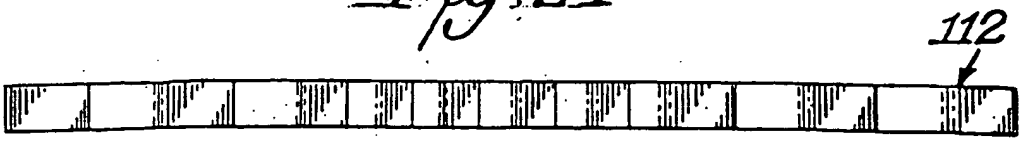


Fig. 23.

Fig. 25.

Fig. 24



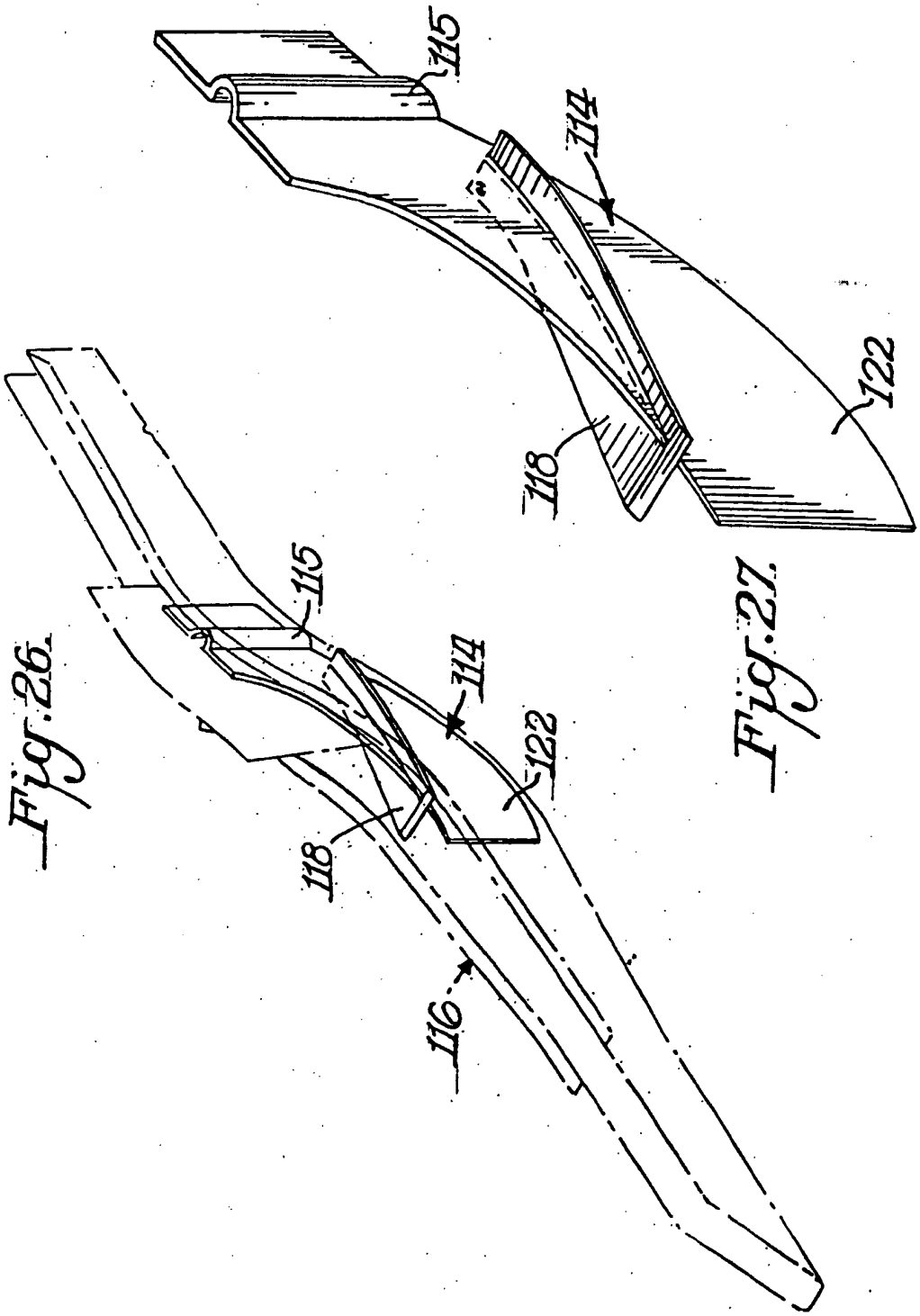


Fig. 26.

Fig. 27.

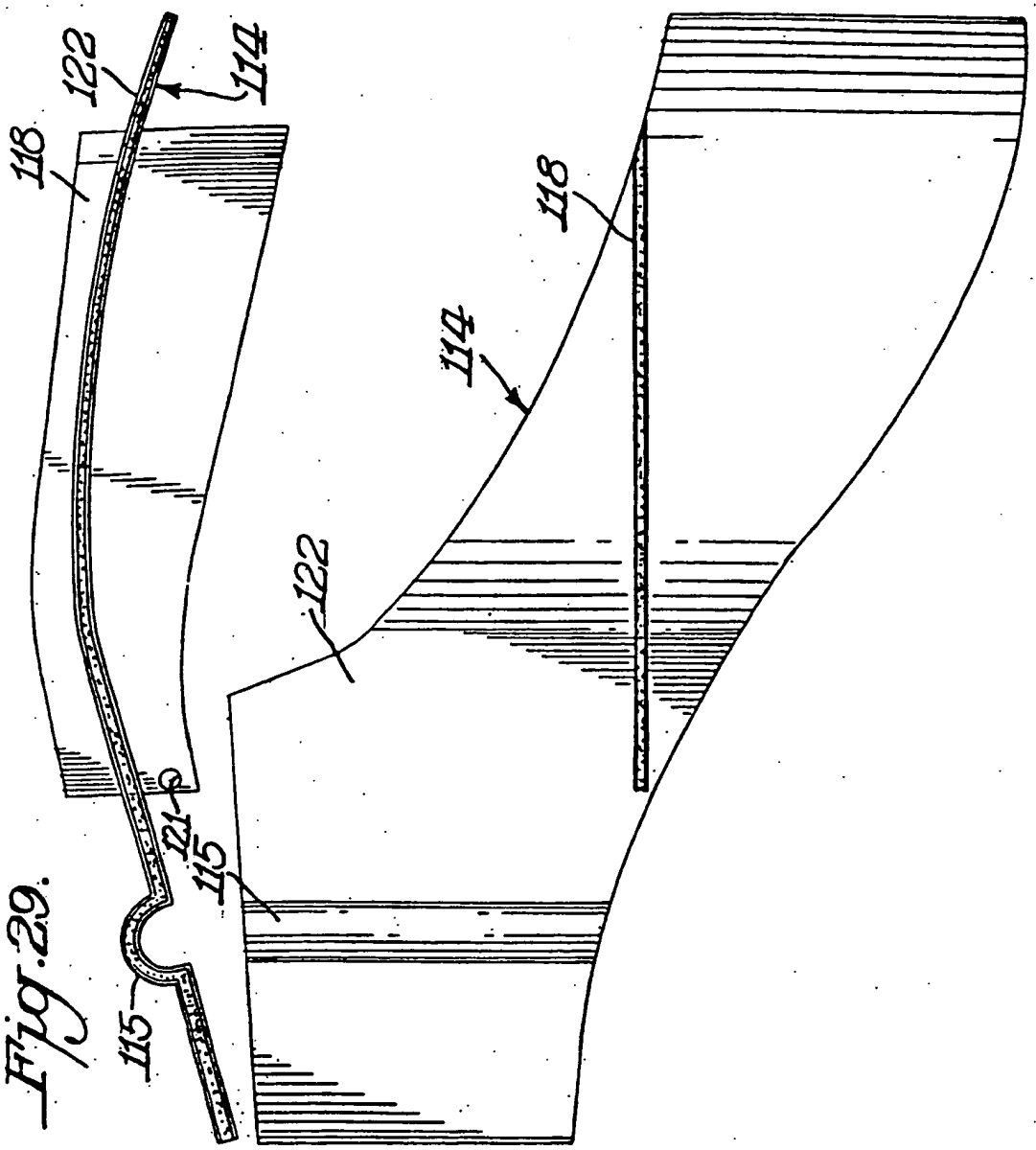


Fig. 29.

Fig. 28.

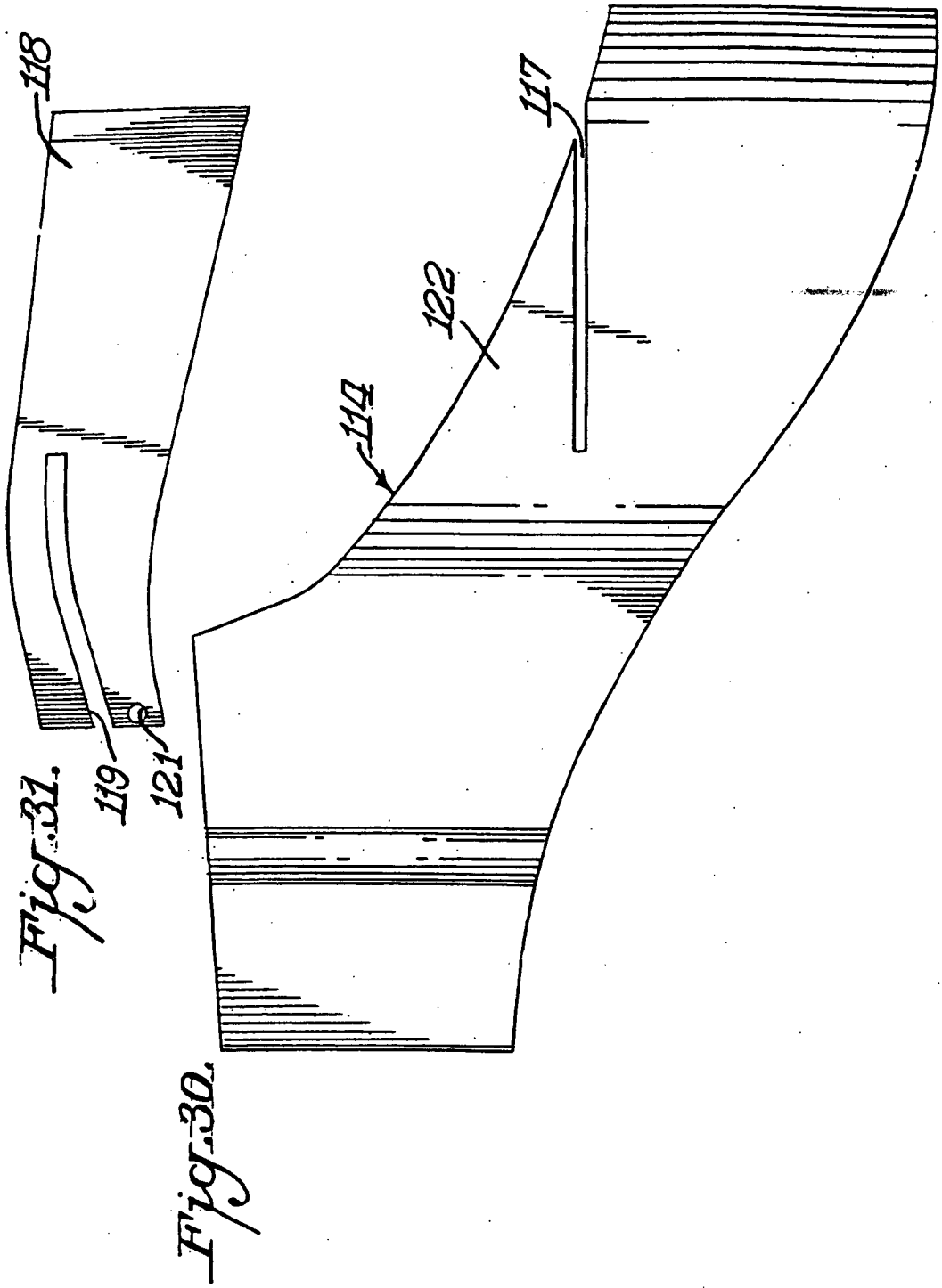


Fig.31.

Fig.30.

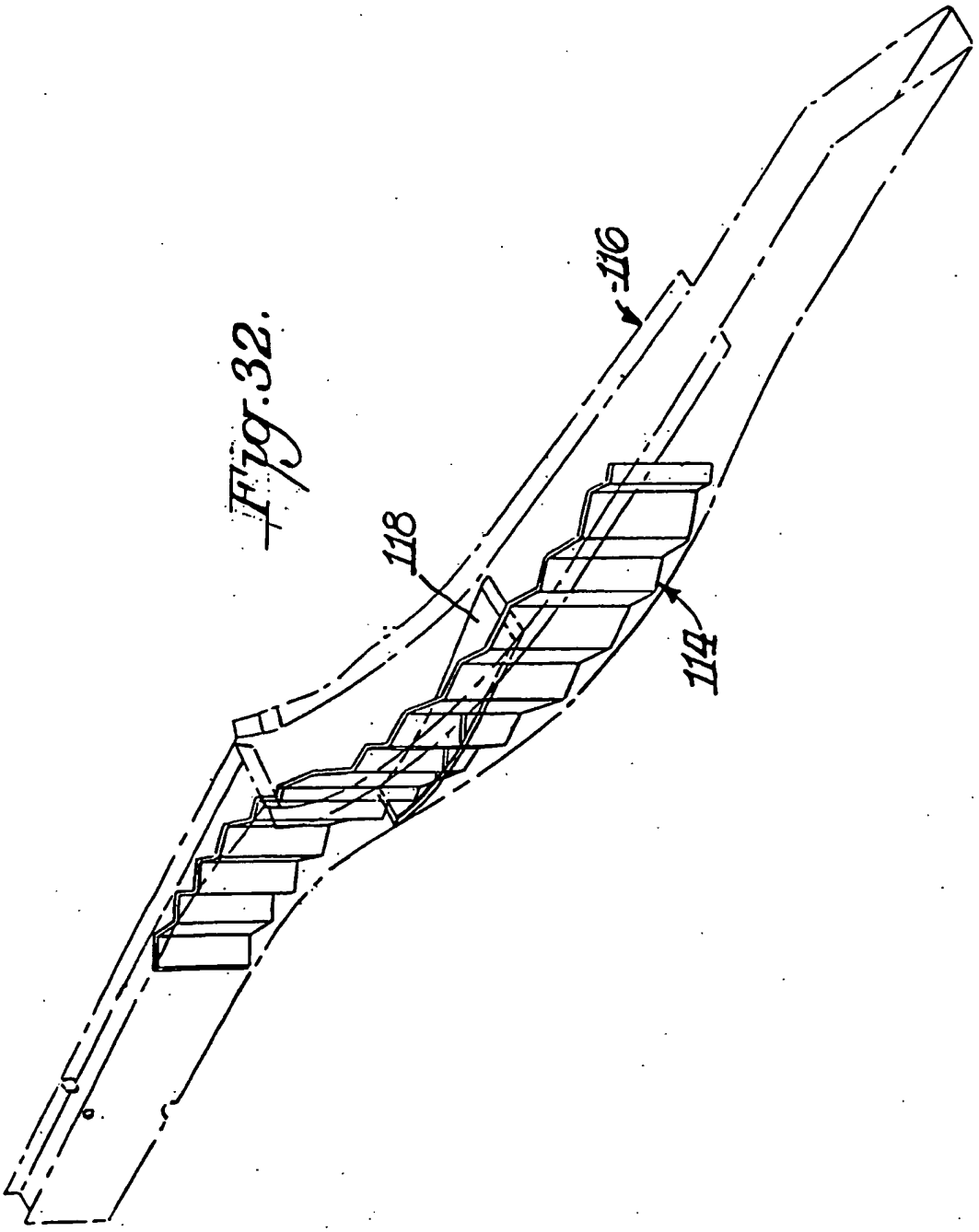


Fig. 32.

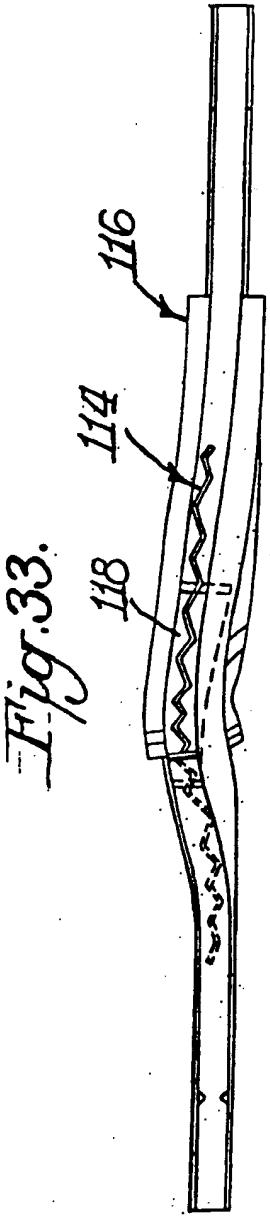


Fig.33.

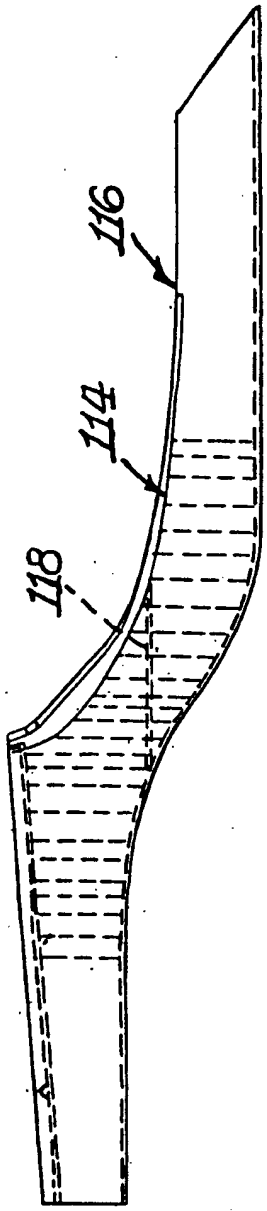


Fig.34.

Fig. 35

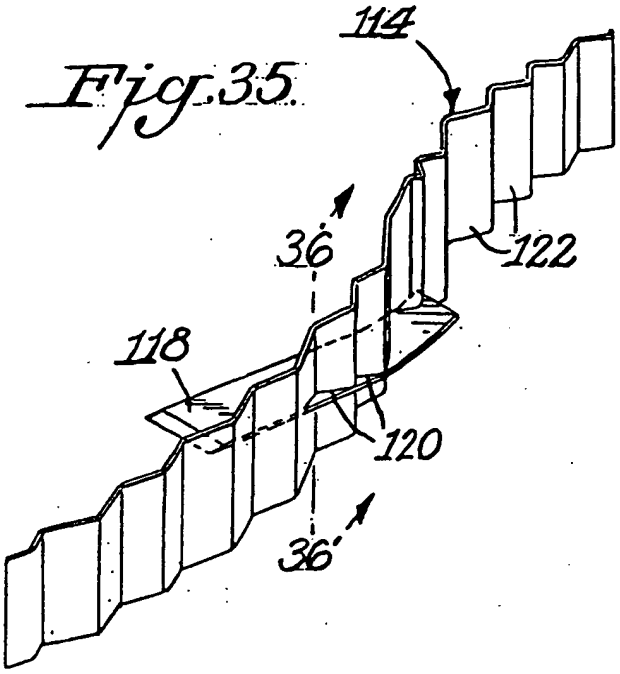


Fig. 36.

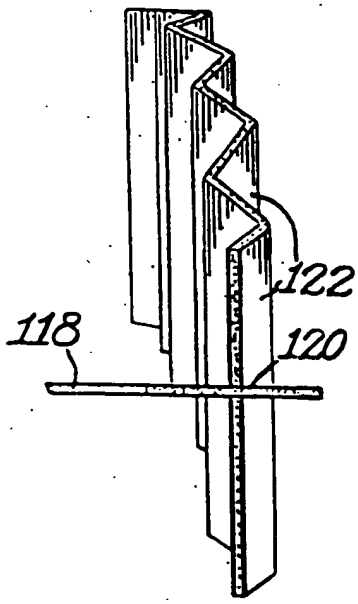


Fig. 37

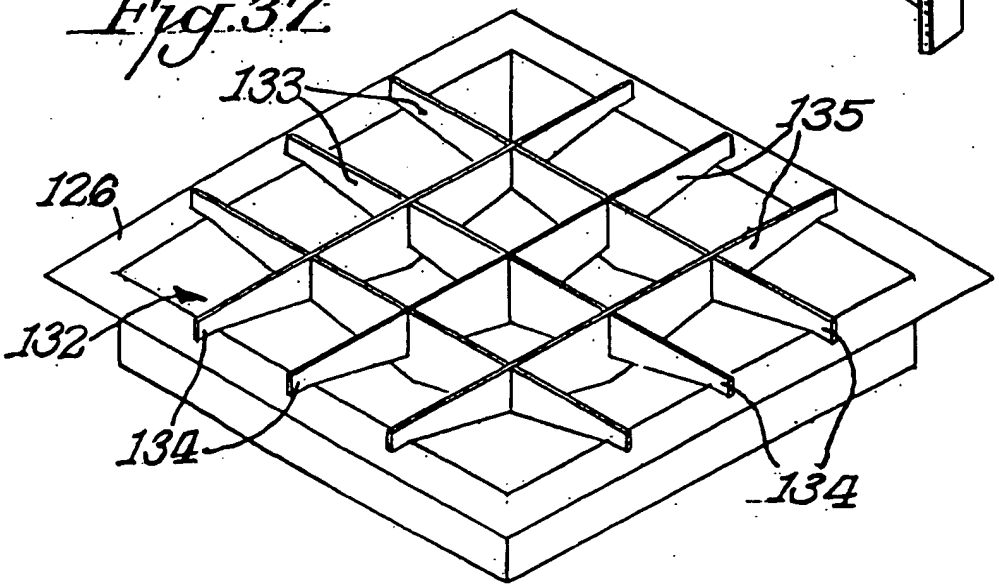


Fig. 38.

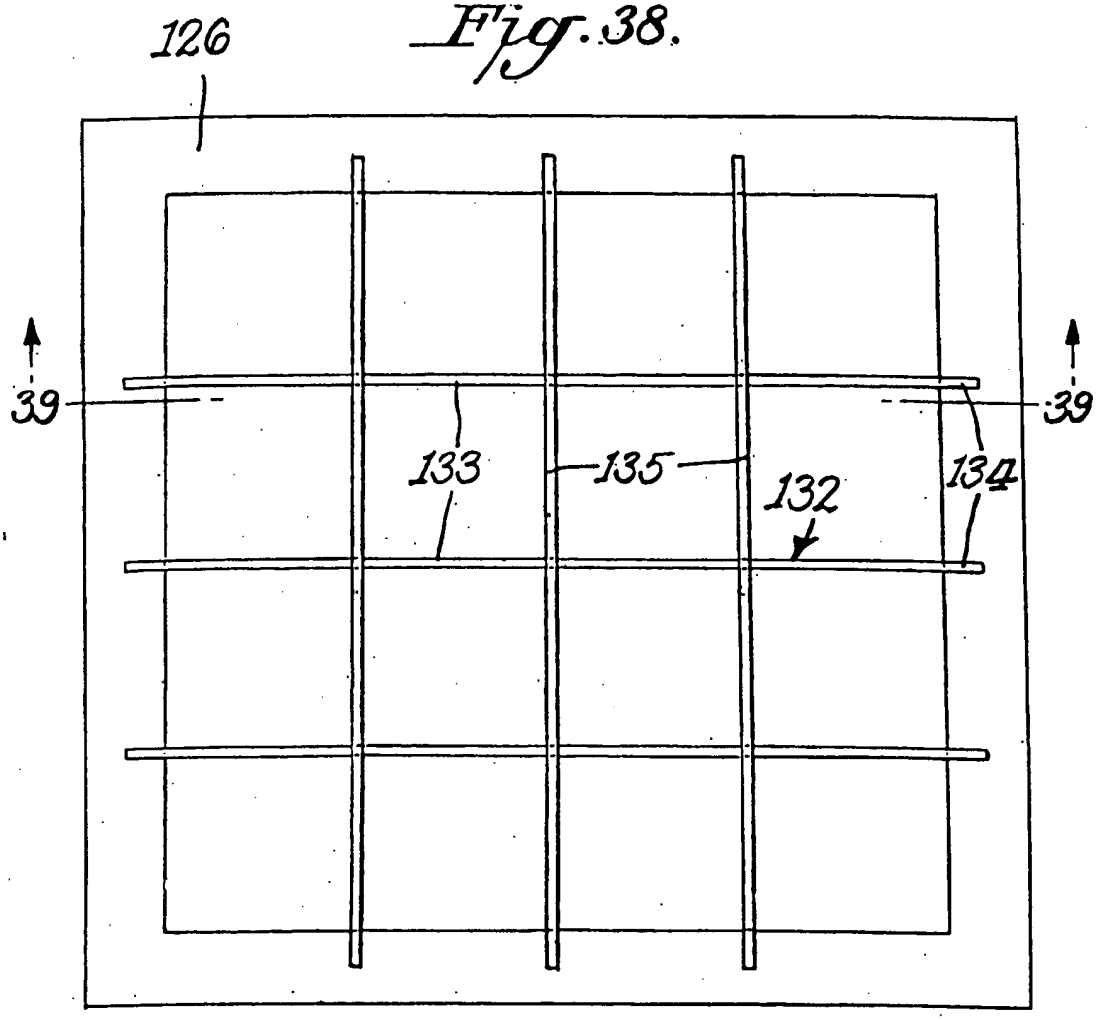


Fig. 39.

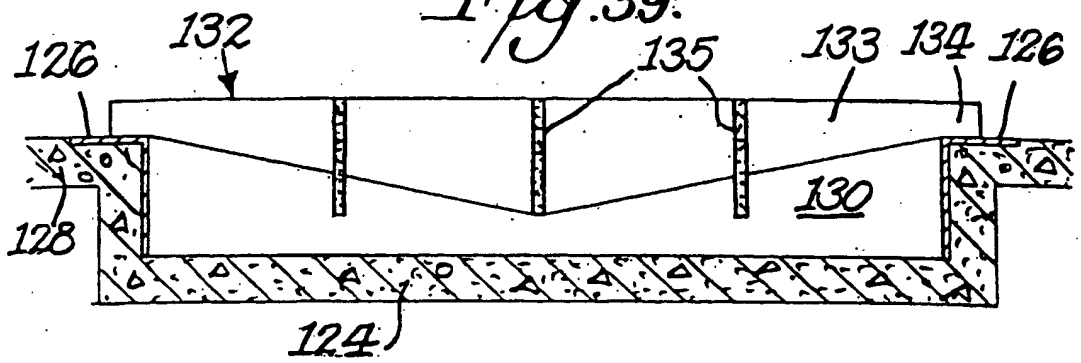


Fig. 41.

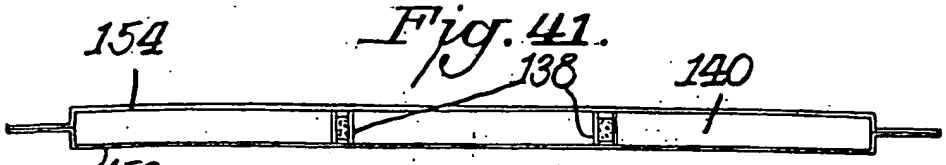


Fig. 40.

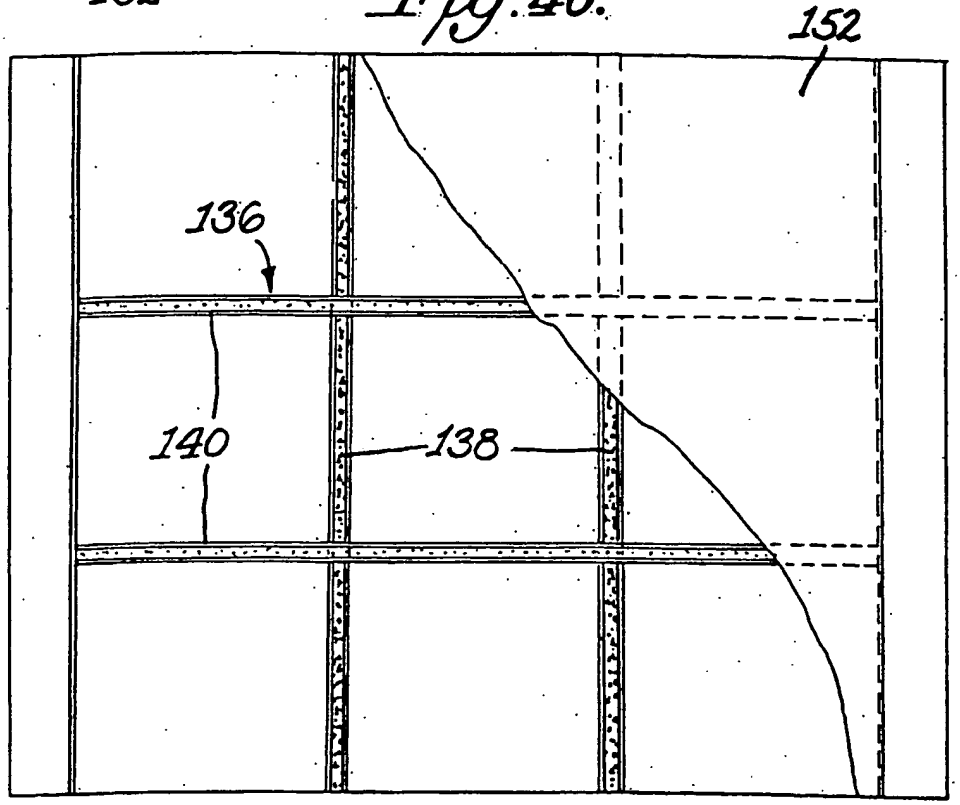


Fig. 42.

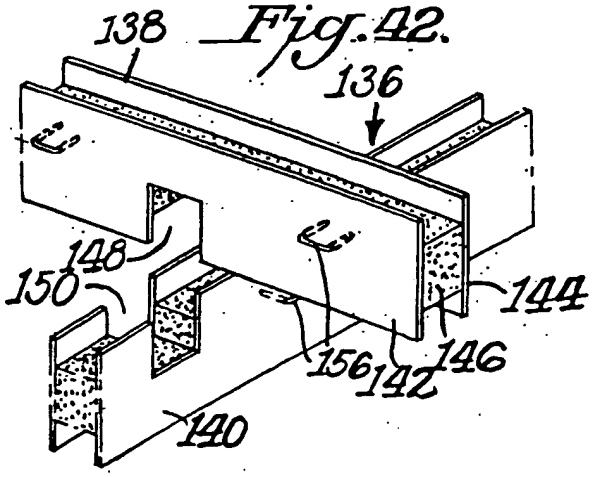


Fig. 43.

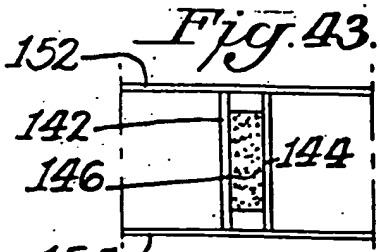


Fig. 44.

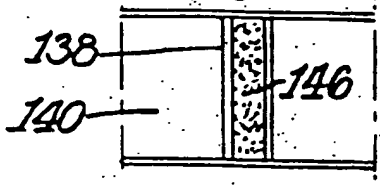


Fig. 45.

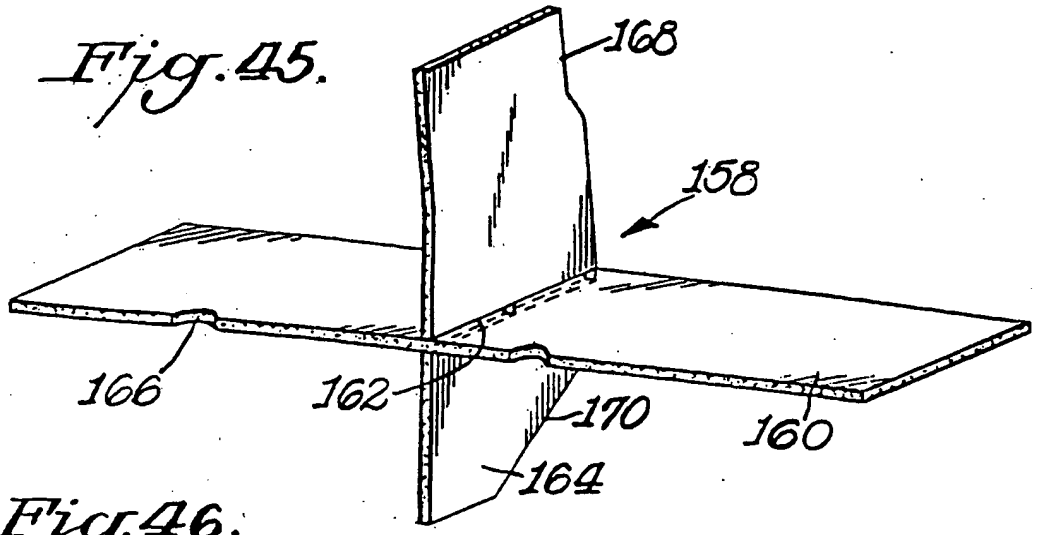


Fig. 46.

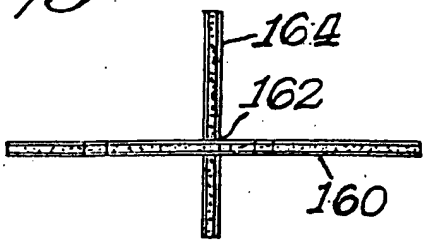
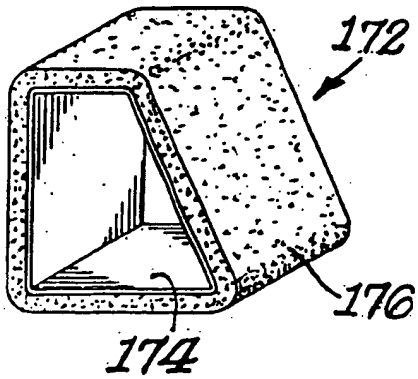


Fig. 47.



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/00497

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :B62D 25/00; E04C 2/26
US CL :Please See Extra Sheet.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 296/188, 30, 901, 209, 203.3, 146.6, 189; 428/35.9, 36.5, 36.91, 31, 304.1, 358; 52/232, 735.1, 309.8, 309.9, 731.3

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

none

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

none

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6,003,274 A (WYCECH) 21 December 1999.	
A	US 5,213,391 A (TAKAGI) 25 May 1993.	
A	US 5,992,923 A (WYCECH) 30 November 1999.	
A	US 5,755,486 A (WYCECH) 26 May 1998.	
A	US 4,923,902 A (WYCECH) 08 May 1990.	
A	US 4,861,097 A (WYCECH) 29 August 1989.	

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
14 APRIL 2000	10 MAY 2000
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	Authorized officer JOSEPH D. PAPE

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/00497

A. CLASSIFICATION OF SUBJECT MATTER:
US CL :

296/188, 30, 901, 209, 203.3; 428/35.9, 36.5, 36.91; 52/232, 735.1

This Page is Inserted by IFW Indexing and Scanning Operations and is not part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☐ FADED TEXT OR DRAWING
- ☐ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☐ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: _____

IMAGES ARE BEST AVAILABLE COPY.
As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.